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PUBLIC HEALTH REPORTS

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LIABILITY OF HEALTH DEPARTMENT.

JUDICIAL DECISION HOLDING THAT A MUNICIPALITY IS NOT LIABLE FOR THE NEGLIGENCE OF ITS HEALTH AUTHORITIES IN THE MAINTENANCE OF AN ISOLATION HOSPITAL.

The Supreme Court of Kansas has decided that a city is not liable in damages for injury resulting from the negligence or misfeasance of officers or employees of the city health department while enforcing laws or ordinances for the protection of the public health.

A patient in a city isolation hospital suffered from blood poisoning as a result of getting into his foot a splinter from the floor. He alleged that the city was negligent in maintaining the floor in a defective condition, but the court said that "the duty of a municipal corporation to conserve the public health is governmental, and it is not liable for injuries inflicted while performing such duty."

The opinion is published in this issue of the Public Health Reports, page 1875.

POLIOMYELITIS (INFANTILE PARALYSIS).

WHAT IS KNOWN OF ITS CAUSE AND MODES OF TRANSMISSION.

By WADE H. FROST, Passed Assistant Surgeon, Uuited States Public Health Service.

In view of the present outbreak of infantile paralysis (poliomyelitis) in New York City the following discussion of the etiology and epidemiology of this disease is taken from Hygienic Laboratory Bulletin No. 90, with some revision by the author. This discussion, based on an extensive review of the literature and on the author's personal studies of the epidemics previously reported, is presented as a summary of the present knowledge concerning the cause and transmission of poliomyelitis, with such opinions as seem justified by the facts.

Means of Transmission.

The essential facts brought out by the experimental studies of poliomyelitis are the following:

The specific cause of poliomyelitis is a minute microorganism, a so-called virus, capable of cultivation in vitro on suitable media.

The virus derived from human cases is pathogenic for apes, producing in them characteristic effects essentially similar to those produced in man. As is the case with many other pathogenic organisms, considerable variations in virulence are noted.

The only animals other than apes which have been found definitely susceptible to the infection are rabbits. The susceptibility of these animals to the infection appears highly inconstant, and the effects produced are both clinically and anatomically quite different from those produced in monkeys. Römer has found guinea pigs susceptible to an infectious paralytic disease strikingly similar to poliomyelitis, and Neustaedter has recently made observations suggesting that the guinea pig may at times be susceptible to poliomyelitis.

Sources of the Virus.

In the human body the virus has been found: (*a*) *In the tissues and secretions of persons dead of poliomyelitis*, namely, in the brain, the spinal cord, the mesenteric glands, the tonsils, and in the mucous secretions of the naso-pharynx, the trachea, and the intestines, (*b*) *In the secretions of persons acutely ill with poliomyelitis*, namely, in the naso-pharyngeal secretions and in washings from the rectum.

The infectivity of these secretions has been demonstrated not only in persons suffering from the clinically typical paralytic forms of poliomyelitis, but also, though less conclusively, in the secretions of those suffering from mild, clinically indefinite, abortive forms.

(*c*) *In the naso-pharyngeal and intestinal secretions of persons convalescent from acute attacks of poliomyelitis.* Although the total number of recorded examinations of convalescents is as yet small, the results of studies by Kling, Wernstedt, and Petterson suggest that in a very large proportion of persons recovering from poliomyelitis these secretions remain infective for several weeks or even months.

(*d*) *In the naso-pharyngeal secretions of apparently well persons* who have been more or less intimately associated with other persons suffering from poliomyelitis, chiefly in epidemic foci. No figures are available as yet to form an estimate of the proportion of persons who, upon exposure to infection with poliomyelitis, become "carriers," or of the relative proportions of carriers and clinically recognizable cases of poliomyelitis in an epidemic focus. The technical difficulties in the way of demonstrating the virus, involving the injection of filtrates into monkeys, are such that extensive statistics upon this point can hardly be expected in the near future, unless the technique of the demonstration can be greatly simplified.

Outside of the human body the living virus has been demonstrated in nature only in the dust of rooms occupied by poliomyelitis patients and presumably contaminated with their secretions, and possibly (though the demonstration is not fully convincing) upon articles recently handled by persons suffering from poliemyelitis.

In brief, there is at present experimental proof of the following sources of infection: *The secretions of persons ill with poliomyelitis, those convalescent from the infection, and "passive carriers"—that is, persons apparently well who are harboring the specific virus and discharging it in their secretions.*

Avenues and Vehicles of Infection.

As to the avenues through which the virus may enter the human body to cause infection, inferences may be drawn chiefly from experiments upon lower animals. Monkeys may be experimentally infected by injection of the virus directly into the brain, or the subdural space, into the general circulation, the peritoneal cavity, or even the subcutaneous tissue. They may also be infected by *rubbing the virus* upon the scarified mucous membrane of the nose, and even by rubbing it *upon the uninjured mucous membrane.* Also, by the use of massive doses of the virus and under quite artificial conditions, it has been found possible to produce infection by feeding monkeys through a stomach tube.

Of the various methods of infection experimentally shown to be possible, infection through the nasal mucosa appears to be the most constant under conditions which might be expected to be approximated in nature.

Concerning the natural vehicles of infection, experiments performed under laboratory conditions are necessarily somewhat inconclusive. The infectiousness of the nasopharyngeal and intestinal secretions of infected persons and the susceptibility of monkeys to infection through the nasal mucosa indicate very strongly that the disease may be transmitted in nature by such vehicles as may serve to transmit these secretions from infected persons to the respiratory (or digestive) tracts of others—that is, by more or less direct personal contact. The resistance of the virus to the influence of drying and sunlight suggests the probability of the infective agent being conveyed in dust and in fomites, a suggestion strengthened by the experimental evidence of the infectivity of dust from the sick room.

Experiments showing the possibility of transmitting the infection from monkey to monkey through the agency of a biting fly, *Stomoxys calcitrans*, and in one instance through the bedbug, have added considerable weight to the hypothesis that poliomyelitis is in nature an insect-borne disease. However, since the transmission of the disease through these insects has proven possible in only isolated instances and under highly artificial conditions, these experiments do not warrant the conclusion that stomoxys or other insects play any important part in the natural dissemination of the disease in man.

On the whole, the experimental evidence, taken alone, while not excluding other means of transmission, points to the conclusion that poliomyelitis is a contagious disease, spread from person to person through interchange of infectious secretions, the sources of infection being the clinically definite and clinically indefinite acute cases of poliomyelitis, convalescents, and passive human carriers.

Epidemiological Characteristics.

To give the epidemiological characteristics of poliomyelitis in general terms is difficult, not only because of the wide variations noted in different epidemics, but also by reason of the comparative paucity of statistics affording but a slender basis for generalization. Still, making due allowance for numerous minor exceptions which can not be noted in a brief discussion, certain general epidemiological characteristics stand out as fairly well established.

1. *Geographic distribution.*—Poliomyelitis is, even in the light of our admittedly imperfect statistics, known to be of practically worldwide distribution. Without attempting to enumerate the localities from which it has been reported, the following examples of localities where epidemics have occurred in recent years may serve to illustrate how far the occurrence of epidemics must be independent of such special climatic or other conditions as are peculiar to any restricted part of the globe.

Since 1905 epidemics have occurred in Europe from Scandinavia to the Mediterranean, from the British Isles to the Danube; in North America from Alaska to Alabama, throughout the breadth of the continent; in the West Indies; in South America; in Australia, and in the South Sea Islands. Thus the disease has occurred in more or less extensive outbreaks in both Eastern and Western Hemispheres, under extremes of latitude from the Equator to the northern Temperate Zone. It is noteworthy, however, that the most extensive outbreaks recorded have been in the northern portions of Europe and in the northern section of the United States, and Canada. The southern sections both of Europe and the United States, while not immune, have suffered less severely.

2. *Seasonal prevalence.*—In respect to season as to climate, poliomyelitis occurs under widely varying conditions. In the latitude of the northern United States cases have occurred, during the last few years, in every month of the year. Nevertheless the disease has a very distinctly characteristic seasonal prevalence, very constantly reaching its maximum both of sporadic and epidemic prevalence during the summer and autumn months, usually during the late summer and early autumn, and declining markedly during the late fall and early winter, to reach its lowest prevalence in midwinter and spring. In the Southern Hemisphere the disease reaches its

maximum prevalence from December to May, the months corresponding to the summer and autumn of northern latitudes. On the Pacific coast of the United States, where the difference between summer and winter is more in the matter of rainfall than of temperature, poliomyelitis has occurred mostly during the dry summer season.

On the whole this seasonal prevalence may be accepted as one of the most constant characteristics of the disease. In respect to the season of maximum prevalence poliomyelitis is in contrast with the more common diseases generally believed to be transmitted by direct contact and to find access to the body through the respiratory tract, such as scarlet fever, measles, diphtheria, whooping cough, etc., which usually reach their highest prevalence in the autumn, winter, and spring. In this respect, its seasonal prevalence, the disease more closely resembles infections of the digestive tract and diseases transmitted by such insects as are most prevalent in summer.

3. *Sporadic and epidemic occurrence.*—Poliomyelitis may be considered to have been endemic, for a considerable number of years at least, in the United States and Europe. Although the statistics are very fragmentary, it would seem a conservative statement that cases now occur every year in every State, and probably in every large city of the United States. Also, at least as regards the large cities, there is good reason to believe that this has been true for a number of years—since long before the disease began to attract attention by its occasional occurrence in epidemics.

This fact is of importance as indicating that the recent epidemics can not be ascribed off-hand to the introduction of a new infection, and that there probably are scattered throughout the country reservoirs of infection, capable of giving rise to the widely scattered so-called sporadic cases.

4. *General characteristics of epidemics.*—In undertaking any generalizations upon the characteristics of epidemics of poliomyelitis, it must be emphasized that to almost any broad general statements there are numerous exceptions, since epidemics vary most strikingly. For example, between the outbreak reported from Hancock County, Iowa, and that in Cincinnati, Ohio, are such radical differences as might be expected between epidemics of two essentially different diseases. Yet, with due regard to the exceptions, the following are believed to be, in general, the essential characteristics of epidemic outbreaks of poliomyelitis, as shown by numerous studies.

(*a*) *Irregular geographic distribution of epidemic foci.*—Almost if not all epidemic diseases affecting man, even those transmitted chiefly from the lower animals or through insects, are disseminated by travel and traffic, and, in their spread from a given point, are naturally expected to follow the chief routes of traffic. It has, however, been noted of epidemics of poliomyelitis that they are often, if not usually, of irregular occurrence, not showing the distribution which would be expected as the result of dissemination along the main highways of traffic.

For example, the epidemic of 1907 in and around New York City, while it apparently extended north into New England, did not extend south to the near-by and intimately connected city of Philadelphia, nor west to the large cities in close communication with New York. The more recent epidemics of 1908, 1909, and 1910, in Minnesota, Nebraska, Iowa, and Kansas, are commonly, and perhaps justly, regarded as sequelæ of the epidemic of 1907 in New York, yet up to this time no epidemic has been recognized in Chicago, through which passes practically all the traffic from New York to the above-mentioned States. Again, in 1910, there occurred a rather severe epidemic in Washington, D. C., and a proportionately smaller outbreak in Philadelphia, while Baltimore, lying between these two cities, and in daily close communication with both, escaped without an epidemic—with at most only an increase in the number of endemic or sporadic cases. Numerous other instances might be cited where epidemics have failed to extend from a given focus to communities which appeared to be most intimately exposed and to offer equal opportunities for the spread of the infection. Such instances alone give the impression that epidemics may be due to a "place infection" not transfered by human travel—an infection of local water or food supplies, of insects or of domestic animals, whose range of travel is generally more restricted than that of man.

(*b*) *Rapid spread over wide areas.*—There are, however, other and almost equally numerous facts which argue against a "place infection" as the cause of epidemics, the chief of these being the rapid spread of epidemics over wide areas, as, for example, the spread over a whole State within a period of a few months. Of such rapid spread over wide areas of country there are numerous instances, in some of which it has appeared upon close study that the spread was in a general way radial from the earliest focus. This is illustrated by the course of the epidemic of 1910 in Iowa, and rather striking instances of similar rapid radial spread are given by Wickman in his account of the epidemic of 1905 in Sweden, and by Kling in his description of the Swedish epidemic of 1911. Such rapid spread over a large territory practically disproves the hypothesis that epidemic outbreaks are due to place infection independent of and not transferred by ordinary human traffic, since it is quite improbable that place infection of numerous localities within the same general territory should develop independently at the same time. The rapidity of spread has, too, in many instances, been such as to confirm the supposition that man, the most rapidly and widely traveling animal, is the carrier of infection.

Both in its rapid spread over large areas and in its irregularity, skipping localities to which it might logically be expected to extend, poliomyelitis finds an analogy in cerebrospinal meningitis, a disease which we now have excellent reasons to believe is directly contagious, being spread from person to person chiefly through the agency of passive human carriers. These characteristics, therefore, do not necessarily indicate insect transmission nor argue against the direct transmissibility of poliomyelitis.

(c) *Small total incidence in the population affected.*—Even during so-called epidemics, poliomyelitis has characteristically a small incidence in the total population. To be sure, instances are not wanting of epidemics in which a large proportion, over 1 per cent, of the total population has been attacked; but these are rather exceptional instances and are practically confined to outbreaks in small towns and small rural areas. In a large aggregation of people, such as the population of a city with over 100,000 inhabitants, a county, or a State, epidemics seldom attack more than one in a thousand of the population, often not more than one in two to four thousand. The incidence of poliomyelitis, therefore, even in epidemics, is frequently less than the usual annual incidence of several of the more common endemic infectious diseases in the same communities, and strikingly less than the incidence which these common diseases frequently attain during epidemics. Notwithstanding this small incidence in the population, epidemics of poliomyelitis are self-limited, invariably declining in any limited area, as a single city or county, within a few months, and as a general if not invariable rule not recurring in that locality for a period of at least two years. This characteristic decline of epidemics after only a very small proportion of the population has been attacked appears not to be due to exhaustion of the sources or the vehicles of infection nor to be dependent altogether upon seasonal conditions. It is, in fact, difficult to account for on any hypothesis other than that of the exhaustion of susceptible material in the population.

(d) *Incidence in rural and urban communities.*—The recent occurrence of epidemics of poliomyelitis in so many countries, under such widely varying conditions, alike in tropical and frigid countries, in densely populated cities and in thinly settled remote country districts, has already been cited as showing conclusively that no set of conditions peculiar to any given locality is necessary for the development of an epidemic. It has, however, been observed as a very general rule that in small towns and in the country epidemics are more intense than in large cities, attacking a larger proportion of the population. This has been found true not only when individual small towns are compared with large cities, but also for groups of all the smaller towns or all the rural population of a State, compared with all the large cities in the same area. The proportionately greater rural prevalence has in fact been so constant as to be unmistakably due not to mere chance but to some fundamental law. It is to be remembered, however, that this applies to epidemics; whether or not the same is true of the endemic or sporadic occurrence of the disease is not fully established. Although the records of the Massachusetts State Board of Health relative to the prevalence of poliomyelitis in that State for five years would seem to indicate that the prevalence has been constantly greater throughout that time in the rural towns than in large cities, yet even there a large proportion of the cases reported each year have occurred in small epidemics scattered throughout the State rather than as sporadic cases.

In respect to its greater rural than urban prevalence, poliomyelitis has often been contrasted to such contagious diseases as measles and scarlet fever, which are quite constantly more prevalent in densely populated cities, and this contrast has been used as an argument against the contagiousness of poliomyelitis.

However, though the endemic prevalence of scarlet fever and measles is greater in large cities, data, which are as yet scant and incomplete, indicate that epidemics, even of these diseases, attain a higher incidence in the population of small towns and rural communities than in the population of large cities. Certainly it is true, at least of measles, that epidemics attain their greatest intensity in communities which have long been free from the infection; witness, for example, the devastating epidemics reported from the Faroe Islands and other remote communities. There is indeed ground for the view that the potential epidemic prevalence of a disease like measles is, in a measure, inversely proportional to its endemic prevalence. Therefore, in regard to poliomyelitis, the fact that epidemics reach a higher incidence in rural districts can not be taken by itself as indicating that rural conditions are necessarily more favorable for the spread of the infection. Before such a conclusion can justly be drawn it will be necessary to show that its endemic or sporadic occurrence is also constantly less in the large cities.

(*e*) *Distribution among the various elements of the population in epidemic foci.*—The close study of epidemics has shown that the incidence of poliomyelitis is proportionately about the same among persons living under good and those living under poor hygienic conditions. This practically eliminates from consideration as of great importance in the causation of the disease such factors as are intimately associated with poor hygienic conditions—such factors, for example, as insufficient and improper food, overcrowding, personal uncleanliness, and association with verminous insects.

No constant difference in regard to the incidence of poliomyelitis has been observed between the different races and nationalities constituting the population of areas where the disease has been epidemic. Nor has any constant relation been shown between the incidence of the infection and the topographic features of the various sections of the affected areas.

In one respect, however, poliomyelitis is constantly and very strikingly selective in its incidence, namely, in respect to age, its greatest incidence being always among children, especially those in the first half decade of life. Children under 5 years of age, constituting, in this country, from 9 to 12 per cent of the total population, furnish usually from 50 to 90 per cent of the cases of poliomyelitis. In some epidemics the disease is almost as prevalent proportionately in children between the ages of 5 and 15 as in those under 5 years of age, but adults (those past the second decade), constituting usually over 50 per cent of the total population, seldom furnish more than 10 per cent of the cases, usually a very much smaller proportion. In the Buffalo epidemic of 1912 the incidence of poliomyelitis in children under 5 years of age was fifty times greater in proportion to their number than in persons from 5 to 24 years of age, while the whole population over 24 years of age, more than 50 per cent of the total inhabitants of the city, remained entirely immune from attack.

As to the significance of this characteristic age incidence of poliomyelitis, its enormously greater incidence in children, it must indicate on the part of the children, either a generally greater exposure to the infective agent or else a greater susceptibility to its effects. So far as I am aware it has never been satisfactorily demonstrated that the children in any large epidemic focus were considerably more exposed to any probable source of infection than were the adults of the corresponding families. To be sure a number of suggestions have been made as to possible ways in which children might be generally more exposed to certain sources of infection than adults. For example, children drink milk more generally and more freely than do adults, but in every considerable epidemic of poliomyelitis of which I am aware, where the data collected have been sufficient, milk supplies could be quite definitely excluded as probable vehicles of infection. Moreover, milk-borne epidemics of other infectious diseases, as typhoid fever and scarlet fever, while characterized by a high rate of incidence in children, are not so strikingly—almost exclusively—confined to children as are epidemics of poliomyelitis. Even the proof that poliomyelitis is characteristically a milk-borne infection would not, therefore, offer an altogether satisfactory explanation of its very excessive incidence in children under 5 years of age and of the almost complete immunity of adults.

Again, on the hypothesis that poliomyelitis may be transmitted by biting insects, it has been suggested that children are more exposed to infection in this way because of their scantier summer clothing and their inability to ward off such insects as readily as do adults. It seems altogether improbable that these considerations are sufficient to account for an incidence fifty times greater in children than in young adults; and, as a matter of fact, epidemic diseases known to be transmitted by biting insects (yellow fever, bubonic plague, typhus fever) are not, in nonimmune populations, characteristically children's diseases.

It has also been suggested that the infection may be commonly contracted from the dust of streets and dwellings, and that children, by reason of their habit of crawling and playing on the ground, are greatly more exposed to infection from this source than are adults. Especially as regards street dust it appears very doubtful that children, as a class, are greatly more exposed than adults, since the latter travel more widely over dusty streets. It certainly seems quite improbable that the exposure of children to dust infection is so enormously greater than that of adults as to account for the peculiar age incidence of poliomyelitis, assuming dust as the chief vehicle of infection.

Finally, because of their less cleanly and individualistic personal habits, children are probably more exposed than are adults to direct contagion through infectious secretions, yet experience teaches that contagious diseases in a nonimmunized, generally susceptible population are not disproportionately prevalent in children. As examples may be cited smallpox in unvaccinated communities, measles in new territory, typhoid fever in communities where contact is the chief factor in its spread.

On the whole it may be said that epidemiologic studies up to this time have failed to demonstrate greater exposure of children than of adults to the infective agent of poliomyelitis, and that the hypotheses put forward to explain an assumed greater exposure are not competent to explain it. The only hypothesis which appears to satisfactorily explain the enormously greater incidence among children is that they are, in general, more readily susceptible to the infection than are older persons.

Poliomyelitis quite commonly attacks both actually and proportionately more males than females. The disproportionate incidence in males, fairly constant in all age groups, is commonly most striking in the ages above 15 years. This is the reverse of what would be expected in a disease transmitted chiefly by direct contact with the sick. Females over the age of 15, being more commonly in contact with the sick in the capacity of nurses, would be expected to develop the infection more frequently than males of the corresponding ages, and such is actually the case with scarlet fever and diphtheria. Since males of this age are more commonly out of doors and away from home than are females, the greater incidence of poliomyelitis among adult and adolescent males than females has very naturally suggested that the disease is usually contracted from some source other than the immediate environment of poliomyelitis patients, perhaps from some outdoor source, as from the soil, domestic animals, or outdoor insects. The greater incidence among males than among females is, however, not altogether incompatible with the view that the disease is really contagious, being transmitted usually through apparently healthy virus carriers. Males, whose business relations generally bring them into contact with more people, would theoretically have more chances of infection from carriers than females, and, assuming equal susceptibility, would more frequently develop the disease.

(*f*) *Local sources and routes of infection.*—Notwithstanding the minute care with which a considerable number of outbreaks of poliomyelitis have been studied, it has almost invariably been impossible to trace, with any degree of accuracy, the exact origin and routes of dissemination of the infection. Among the exceptions to this statement may be noted some of the small outbreaks described by Wickman, where it was possible to trace fairly definite lines of direct and indirect contact between cases; also a small outbreak, likewise reported by Wickman, where the evidence suggested that the infection had been spread through a common milk supply. These, however, are exceptional instances. In general the epidemiologic study of outbreaks has yielded only negative results. The very fact, however, that the results of study are usually negative has a certain significance.

For example, mass infection of common water and food supplies has been quite generally and definitely eliminated as a probable means of dissemination in the epidemics studied.

It has already been noted that it is usually impossible to trace any definite connection between the incidence of the disease and the immediate environmental conditions under which the various elements of the population live. This is rather strong evidence that the spread of infection is largely independent of such factors as overcrowding, improper feeding, personal uncleanliness, and the presence of vermin.

In a general way, the incidence of poliomyelitis in different communities has appeared to be roughly proportional to the number of domestic animals present. This is, however, perhaps only another method of stating that the disease has been commonly most prevalent in rural and semirural communities, where domestic animals are usually more numerous in proportion to the population than in large cities. There is no conclusive evidence of a characteristically greater incidence of infection among those persons who, by reason of their occupation or their residence, are most closely and intimately associated with domestic animals.

Domestic animals suffering from paralytic affections, clinically similar to poliomyelitis, have often been found in communities where poliomyelitis was epidemic, but these animals have not appeared sufficient, either in numbers or in the intimacy of their association with cases of poliomyelitis, to account for the epidemics. Also, it has not been shown that the paralyses of animals are essentially similar to human poliomyelitis. Paralytic diseases of lower animals are not very uncommon, and though they have not been fully studied it appears that they may be due to a variety of causes. It is not even proven that such diseases are actually more common during epidemics of poliomyelitis. It is quite possible that their apparent association with epidemics of poliomyelitis is due to the fact that they are more apt to be noted and reported in communities where the epidemic prevalence of poliomyelitis has attracted attention to them.

Peculiar topographical or meteorological conditions can not be held to account for epidemics, since, as already noted, the range of such conditions under which epidemics have occurred is very wide. The unprecedented prevalence of poliomyelitis in certain sections of the United States in 1909 and 1910, during unusually dry seasons, gave considerable color to the hypothesis that deficient rainfall, with the consequent excessive prevalence of dust, was an important factor in the causation of epidemics, but broader experience has not confirmed this supposition. The fact that an epidemic of poliomyelitis may be declining in one community while in another, so near by as to be under approximately identical meteorological conditions, an epidemic may just be developing, is a further indication that the development and decline of epidemics are to a considerable extent independent of the weather conditions.

The evidence in regard to the contagiousness of poliomyelitis may be considered from two points of view: First, from the incidence of the disease among persons known to have been intimately associated with poliomyelitis patients, and second, from the proportion of recognized cases in which evidence could be obtained of association with previous cases.

The statistics presented in this report show that of 2,070 persons exposed to poliomyelitis by residence in the same houses and same families as poliomyelitis patients, only 14 (0.6 per cent) developed the disease in frank paralytic form. Even assuming that all of these actually contracted their infections from association with the sick members of their families, the contagiousness of poliomyelitis must still be very slight—less than one-fifteenth that of scarlet fever, as shown by Chapin's extensive statistics, compiled on a similar basis. The inclusion of *abortive* cases, which, though not developing paralysis, may be conservatively diagnosed as poliomyelitis, approximately doubles the apparent contagiousness, which is still further increased (to 3.2 per cent) by the inclusion of less definite *suspected* cases. Yet, even including these indefinite suspicious cases, it is only in exceptional small outbreaks that the attack rate of poliomyelitis among exposed persons approximates that of scarlet fever or diphtheria. Similar evidence of the slight contagiousness of poliomyelitis has been afforded by its very small incidence among large groups of children exposed to contagion by association, in schools and institutions, with acute cases. The exceptions to this, as the outbreak reported in Hancock County, Iowa, and some small outbreaks reported by Wickman, do not invalidate the general truth of the statement, which is supported by a large mass of more or less definite observations reported by numerous observers from all parts of this country and Europe.

Taking up the evidence of contagiousness from the other point of view, namely, by attempting to trace cases back to association with previous cases, the statistics presented in this report agree with the observations made in most epidemics, that only a small proportion of cases can be ascribed to known contact with previous definite cases of poliomyelitis. Even including association with merely suspicious cases of illness, the majority of cases of poliomyelitis can not be traced to known contact, either direct or indirect, with any previous case. It is this apparent lack of relation between cases which has led so many investigators to seriously doubt or even deny the transmissibility of the disease.

On the whole it may be fairly definitely concluded that if poliomyelitis is transmissible from person to person through either the respiratory or the gastrointestinal excretions, it must be rather slightly or rarely transmissible, since the disease develops in such a small proportion of persons known to be intimately associated with acute cases. It also seems well established that the recognized cases of the disease must be relatively unimportant sources of infection. This follows necessarily, because a large proportion of the cases studied have been in persons not associated in any known way with previous recognized cases—often under circumstances which precluded the possibility of even indirect contact unless through the intervention of not one but a series of unrecognized carriers. In short, if poliomyelitis is a contagious disease confined to human beings, as certainly seems most probable at this time, the chief sources of infection must be cases of illness not recognized as poliomyelitis, or, more probably, apparently healthy carriers of the virus.

(*g*) *Evidence of transmission by insects.*—Aside from the evidence that poliomyelitis may be transmitted experimentally from infected monkeys by biting insects (bedbugs and stable flies), and that the virus may be mechanically carried upon and in the bodies of common house flies, the evidence in favor of the view that the disease may be in nature insect-borne is based upon certain broad epidemiological peculiarities and the results of intensive study of local outbreaks.

The broad epidemiological peculiarities which at once suggest that some insect is a necessary agent in the transmission of poliomyelitis are a seasonal prevalence corresponding to the season of maximum prevalence and activity of numerous insects; greater intensity of epidemics in rural than in urban communities; and the irregular spread of epidemics, suggesting that some local factor as yet unrecognized must be present in order that an epidemic may develop.

The insects which can merit consideration as necessary or even important factors in the transmission of poliomyelitis may be expected to exhibit the following characteristics:

Distribution over an approximately world-wide territory.

Maximum prevalence and activity during the late summer and fall months, but in the North Temperate latitudes a certain though diminished prevalence and activity throughout the year.[1]

Prevalence in large cities, small towns, and rural districts.

Comparatively uniform distribution among the various social strata, among persons living under good and those living under poor hygienic conditions.

As to the seasonal prevalence of poliomyelitis, it is not so definitely limited to the warmer months as would be expected if the disease is transmitted by some outdoor insect, such as mosquitoes or biting flies. It has certainly not the sharply defined seasonal prevalence of yellow fever. On the other hand, it has a more sharply defined summer and autumn prevalence than would be expected in a disease transmitted by insects more strictly parasitic to man, as bedbugs, lice, and fleas. Typhus fever transmitted by the louse is rather a winter than a summer disease, and bubonic plague transmitted by fleas is by no means limited in its prevalence to the warm seasons.

As noted elsewhere in this report and in previous publications, the seasonal prevalence of poliomyelitis corresponds in a general way to that of typhoid fever, especially to that of rural typhoid and the "residual" typhoid of cities with good water supplies; and even more closely to the seasonal prevalence of infantile diarrhea and enteritis. Therefore, while the seasonal prevalence of poliomyelitis is markedly dissimilar to that of most so-called contagious diseases believed to be respiratory infections, it is at least as nearly like that of digestive-tract infections as of any known insect-borne disease.

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[1] Cases of poliomyelitis occurring during the winter months may possibly be explained as having been contracted during the summer or fall and developing only after a very prolonged incubation, but this can be considered only as a mere surmise.

The greater rural than urban intensity of epidemics of poliomyelitis has already been discussed, and mention made of the fact that the data now available do not prove the existence of more favorable conditions for the spread of infection in rural communities; they may even be interpreted as indicating a lesser rate of endemic prevalence in the latter than in large cities.

The fact that the most careful study of discrete outbreaks has often failed to discover any avenues of contact between cases has suggested to a number of students of the subject that the infection was disseminated through insects capable of traveling or being carried for considerable distances. The assumption that insect transmission offers any explanation of the scattering rather than grouping of cases is of doubtful validity, contradicted rather than supported by actual observation of epidemic diseases known to be transmitted by insects. Certainly the grouping of cases in close proximity to each other or their association with some definite focus is quite characteristic of epidemics of yellow fever, typhus, bubonic plague, and fly-borne epidemics of typhoid fever. The traveling habits of the stable fly might appear to account for the occurrence of cases of poliomyelitis in persons at a considerable distance from the original source of infection, but even so it would be expected that if this were the usual method of transmission cases would be more grouped in localities where these flies are strikingly abundant, as in the vicinity of large stables, and that infection would be noticeably common in persons whose occupation greatly exposes them to the bites of stomoxys, as teamsters and hostlers.

Again, two facts which fail utterly of explanation by the theory of insect transmission per se are the small total incidence of poliomyelitis, and more especially its preponderating incidence in children. Diseases known to be insect borne are not characteristically more prevalent in children than in adults, nor is there any obvious reason why they should be unless children are more susceptible to the infection. The hypothesis of insect transmission, therefore, like that of transmission by direct contagion, leads back to the assumption of general immunity to the infection on the part of adults and to unrecognized sources of infection.

On the whole, while there is much to suggest that poliomyelitis is insect borne, its epidemiology appears to be equally well explained on the theory of direct transmissibility through infectious secretions, and the latter theory is at present supported by more experimental evidence than is the theory of insect transmission.

Summary.

Reviewing briefly the data and considerations which have been discussed, poliomyelitis is due to a specific infective agent, of which the only demonstrated natural sources are infected[1] human beings, who may be divided into the following groups: The recognized sick, convalescents, the sick not recognizable as poliomyelitis cases, and passive virus carriers apparently in good health. The infective agent is known to be discharged from these sources in the excretions of the respiratory and digestive tracts; it is known to be fairly resistant to the destructive agencies encountered in nature outside of the human body. Perhaps the most significant fact in regard to the experimental transmission of poliomyelitis to monkeys is that they may be infected by rubbing the virus on the nasal mucous membrane. Infection through the digestive tract or through the agency of biting insects has been found more difficult and less constant.

The disease is, in nature, of widespread though rare sporadic or endemic occurrence. In epidemics it has occurred in recent years over a large part of the world, the outbreaks being sometimes discrete, at other times spreading rapidly, but irregularly, over wide areas. Such epidemics characteristically run a rather rapid course in a given community, declining after a few months or less, after having attacked (so far as is evident) only a small proportion of the total inhabitants, usually not more than one in a thousand; and do not recur in the same locality for a period of at least two years. In epidemic foci children under 5 are attacked much more often than are older persons, the whole adult population remaining virtually immune in some epidemics.

The rapid spread of epidemics over wide areas, their spontaneous decline after only a small proportion of the inhabitants have been attacked, and above all the preponderating incidence in young children have not been satisfactorily explained by any hypothesis other than that the infective agent, during epidemics, is widespread, reaching a large proportion of the population, but only occasionally finding a susceptible individual, usually a young person, in whom it produces characteristic morbid effects. Assuming this rare susceptibility, the well-established facts collected by epidemiologic studies are compatible with the evidence of laboratory experiments that the disease is directly transmissible from person to person.

As to what constitutes susceptibility or the converse—immunity—practically nothing can be deduced except that age is obviously a factor of importance, susceptibility being generally greatest in the first half decade of life, thereafter progressively diminishing until in adult life there is a very general immunity to natural infection. The reason for this is at present a matter of speculation. Conceivably the greater immunity of adults may be due to a nonspecific resistance, developing naturally with maturity, without reference to previous exposure to or infection with the specific virus of poliomyelitis. On the other hand, there are certain facts which suggest that the very general immunity of adults may be specific, acquired from previous unrecognized infection with the virus of poliomyelitis. This, however, is at present merely a speculative suggestion.

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[1] Under the term "infected human beings" as used here are included passive carriers of the virus, persons in whom the virus has found lodgment and multiplied, without, however, producing clinically evident effects. Such persons should, perhaps, be called "infested" rather than infected, reserving the latter term for those manifesting a clinical reaction.

POLIOMYELITIS.

VERMONT PUTS RESTRICTIONS UPON CHILDREN FROM NEW YORK CITY.

On July 6 the State Board of Health of Vermont issued regulations in regard to the supervision and quarantine of children under 15 years of age coming into the State from New York City. The text of the regulations will be found in full on page 1879.